AJ

10/817,445

PATENT SPECIFICATION

(11) 1 466 486

1 466 486

(21) Application No. 179/75 (22) Filed 3 Jan. 1975 (19)
(31) Convention Application No. 431 042 (32) Filed 7 Jan. 1974 in
(33) United States of America (US)
(44) Complete Specification published 9 March 1977
(51) INT. CL.^{2} H04B 9/00
(52) Index at acceptance
G1A 205 207 246 247 248 269 30Y 342 356 357 358 359 369 373 374 568 578 579 580 589 58Y 590 599 59Y 718

THE PATENT OFFICE LONDON

(54) OPTICAL COMMUNICATION SYSTEM SOURCE-DETECTOR PAIR

(71) We, CORNING GLASS WORKS, a corporation organised under the laws of the State of New York, United States of America, of Corning, New York 14830, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to optical communication systems.

The continually increasing amount of traffic that communication systems are required to handle has hastened the development of high capacity systems. Even with the increased capacity made available by systems operating between 10^9 Hz and 10^{12} Hz, traffic growth is so rapid that saturation of such systems is anticipated in the very near future. High capacity communication systems operating around 10^{15} Hz are needed to accommodate future increases in traffic. These systems are referred to as optical communication systems since 10^{15} Hz is within the frequency spectrum of light. Conventional electrically conductive waveguides which have been employed at frequencies between 10^9 and 10^{12} Hz are not satisfactory for transmitting information at carrier frequencies around 10^{15} Hz. The transmitting media required in the transmission of frequencies around 10^{15} Hz, which are referred to as optical signal transmission lines, may consist of a single optical waveguide or a bundle thereof. Present low loss optical waveguides consist of an optical fibre having a transparent core surrounded by a layer of transparent cladding material having a refractive index which is lower than that of the core.

To establish an optical communication network between a plurality of stations, a variety of interconnection schemes may be utilised. Each station can be "hard wired" to each of the remaining stations, or networks such as loop and line data buses may be employed. Regardless of the type of interconnection scheme that is employed, a part thereof usually includes an optical waveguide bundle in which information transmission occurs in two directions. The point of termination of this bundle at a station must include means for initiating the propagation of light wave energy in the bundle and means for detecting that light wave energy which radiates from the bundle. The light detector and light emitter are often remotely disposed with respect to one another and must be optically connected to the bundle endface by such optical components as prisms, mixers, additional waveguide bundles and the like.

It is therefore an object of the present invention to provide a single compact device for disposition at the endface of an optical waveguide bundle for injecting optical wave energy into the bundle and extracting and detecting energy propagating therein.

According to the present invention, there is provided an optical waveguide termination system adapted to be positioned in axial alignment with an end portion of an optical waveguide bundle bi-directionally propagating optical signals, for injecting optical wave energy into the bundle and extracting and detecting energy propagating therein, and provided with an optical mixer means with a first end face adjacent to an end face of the end portion of the waveguide bundle, a solid state light detector adjacent to the opposite, second end face of the mixer means, an edge emitting solid state light source on the side of the detector opposite the mixer means, and reflecting means so disposed with respect to the source as to reflect light emitted from a source to the second end face of the mixer means.

In the accompanying drawings:

Figure 1 is a cross-sectional view of an optical waveguide bundle termination device, and

Figure 2 is a cross-sectional view of a further embodiment of the present invention.

Figure 1 is a cross-sectional view of an optical waveguide bundle termination device constructed in accordance with the present invention. It is to be noted that the drawing is not to scale and merely serves to illustrate the present invention. The end portion of a bundle 10 of optical waveguides 11 is

disposed in a termination ferrule 12 which maintains the end portions of waveguides 11 in parallel alignment. The ends of the optical waveguides and the ferrule are ground and polished so that each waveguide terminates in an end face that is substantially perpendicular to the axis thereof, and all of the waveguide end faces lie in a single plane and form the bundle end face. Ferrule 12 preferably consists of a material such as glass, brass or the like which has grinding characteristics similar to those of the waveguide material.

The end face of bundle 10 is disposed adjacent to a first end face 16 of an elongated transparent mixer rod 18. A second end face 20 is located opposite end face 16, and both end faces are preferably perpendicular to the longitudinal axis of rod 18. Rod 18 is preferably in the shape of a cylinder of circular cross-section, but other suitable cross-sectional shapes may be employed. The outer surface of rod 18 cooperates with the surrounding medium to provide an optical quality interface for reflecting back into the rod any light that is incident thereon. Such an interface is preferably provided by layer 22 of transparent cladding material having a refractive index sufficiently lower than that of rod 18. As used herein, the term "transparent" indicates transparency to those wavelengths of light that are to be transmitted by optical waveguides 11. Mixer rod 18 is disposed in a flanged support member 24 which is secured to ferrule 12 by connecting means 26.

A light source-detector pair 30 including solid state source 32 and solid state detector 34, is disposed adjacent to end face 20. The light source is an edge-emitting diode, preferably a type such as a double-heterojunction, large optical cavity (LOC) laser diode. The LOC laser diode is fabricated such that the light generated therein is "waveguided" and must emerge parallel to the plane of the junction, rather than normal to the junction through the planar top and bottom surfaces. Edge-emitting laser diodes can be operated continuously at room temperature at currents below the lasing threshold current as incoherent emitters, i.e., as LED's while preserving the feature of edge emission. Two commercially available edge-emitting devices are the RCA (registered Trade Mark) model C30034 LOC laser diode and the Spectronics (Registered Trade Mark) model SE-2430 edge-emitting LED. Diode source 32 is provided with a large electrical contact 36 which also serves as a heat sink. Contact 36 is supported by housing 38. The remaining electrical connection to diode source 32 is provided by flying lead 40.

The light detector 34 may be a conventional p-i-n or avalanche photodiode. Some commercially available diodes suitable for use as detector 34 are the EG&G model SGD-040A PIN diode and the Texas Instruments model TIXL-59 avalanche diode. Electrical connection is made to detector 34 through beam lead 42 and flying lead 44. Beam lead 42 is also employed to initially support detector 34 during the manufacture of source-detector pair 30.

An edge-emitting diode source is employed since detector 34 is disposed between the source and mixer 18. The interior surface of housing 38 is therefore provided with a reflective surface 48 to reflect light emitted by source 32 toward rod 18. Because of the low numerical aperture of presently available low loss optical waveguides, surface 48 should reflect light from source 32 to form a beam that is as nearly collimated as possible. Light reflecting surface 48, which is illustrated as being parabolic, may be formed by depositing a thin layer 50 of light-reflecting material such as silver, chromium or the like upon the cavity forming inner surface 46 of housing 38. Alternatively, housing 38 could consist of a material, the surface of which could be polished to form light-reflecting surface 48. Obviously, the various metallic leads and electrical contacts to source 32 and detector 34 must not contact metallic members such as reflecting layer 50, and all electrical contacts and leads are therefore suitably insulated.

Detector 34 is held rigidly in place by filling the cavity within housing 38 with a suitable transparent adhesive 54. Such adhesives include silicon fluid, ethylcyanoacrylate epoxy, methyl siloxane, and the like. Many suitable adhesives are described in a compilation distributed by National Technical Information Service entitled "Properties of Optically Transparent Adhesives" by W. H. Veazie, June 1972, publication No. EPIC-IR-76 (revised).

Light propagating in optical waveguides 11 radiates therefrom inter mixer rod 18. As illustrated by dashed lines 58 this light emanates from mixer rod 18 and impinges upon detector 34. If the surface 56 of adhesive 54 is formed in the shape of a lens, light represented by lines 58 is concentrated on to the surface of detector 34, the area of which is less than that of mixer end face 20. Light is preferably radiated radially in all directions from source 32 which is disposed at the focus of the parabolic reflecting surface 48. After reflecting from surface 48, this cylindrical "shell" of light represented by dashed lines 60 is directed toward end face 20 of mixer rod 18. If surface 56 is lens-shaped, the reflected source light is concentrated toward the system axis as indicated by lines 62. This is especially desirable when the dimensions of the detector and source are almost as large as end face 20,

in which case it is necessary to concentrate light emitted from the source so that it can impinge upon end face 20.

In the embodiment of Figure 2, wherein elements similar to those of Figure 1 are represented by primed reference numerals, the surface of transparent adhesive 66 is flat and contacts the second end face of the mixer rod. The interior surface of housing 68 is provided with a concially shapel layer 70 of light-reflecting material. In this embodiment the source-detector pair is monolithically formed by disposing detector 34' directly upon an insulating layer 72 which covers the surface of source 32'. Such a monolithic structure could also be formed by growing additional epitaxial layers on the surface of the source diode. Since detector 34' is supported by source 32', transparent adhesive material 66 could be omitted. In this case, mixer rod 18' could be disposed directly upon the surface of detector 34'.

WHAT WE CLAIM IS:—

1. An optical waveguide termination system arranged to be positioned in axial alignment with an end portion of an optical waveguide bundle bi-directionally propagating optical signals, for injecting optical wave energy into the bundle and extracting and detecting energy propagation therein, and provided with an optical mixer means with a first end face adjacent to the end face of the end portion of the waveguide bundle, a solid state light detector disposed adjacent to the opposite, second end face of the mixer means, an edge emitting solid state light source on the side of the detector away from the mixer means, and reflecting means so disposed with respect to the source as to reflect light emitted from a source to the second end face of the mixer means.

2. A system as claimed in Claim 1 further comprising means between the detector and the second end face of the mixer for concentrating the light rays on the surface of the detector.

3. A system as claimed in either preceding Claim further comprising a housing having a wall forming a cavity therein, the source and the detector being potted in the cavity by a transparent adhesive, the light reflecting means being disposed on the cavity forming wall of said housing.

4. A system as claimed in Claim 3, wherein the surface of the adhesive which faces the second end face of the mixing means is curved to concentrate light reflected from the reflector onto the second mixer end face.

5. A system as claimed in Claim 4 wherein the curved surface of the adhesive is spaced from the second mixer end face.

6. A system as claimed in Claim 5 wherein the detector is spaced from the said source.

7. A system as claimed in Claim 6 wherein the cavity forming wall of the housing is parabolically shaped.

8. A system as claimed in Claim 5 wherein the detector is disposed upon a surface of the source.

9. A system as claimed in Claim 3 wherein the area of the surface of the detector facing the mixer means is smaller than that of the second end face of the mixer means.

10. A system as claimed in Claim 9, wherein the second end face of the mixer means is in contact with adhesive, the surface of the adhesive which contacts the mixer means being flat.

11. An optical waveguide system substantially as described with reference to the accompanying drawings.

ELKINGTON AND FIFE,
Chartered Patent Agents,
High Holborn House,
52/54 High Holborn,
London, WC1V 6SH.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1977.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

1466486 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig. 1

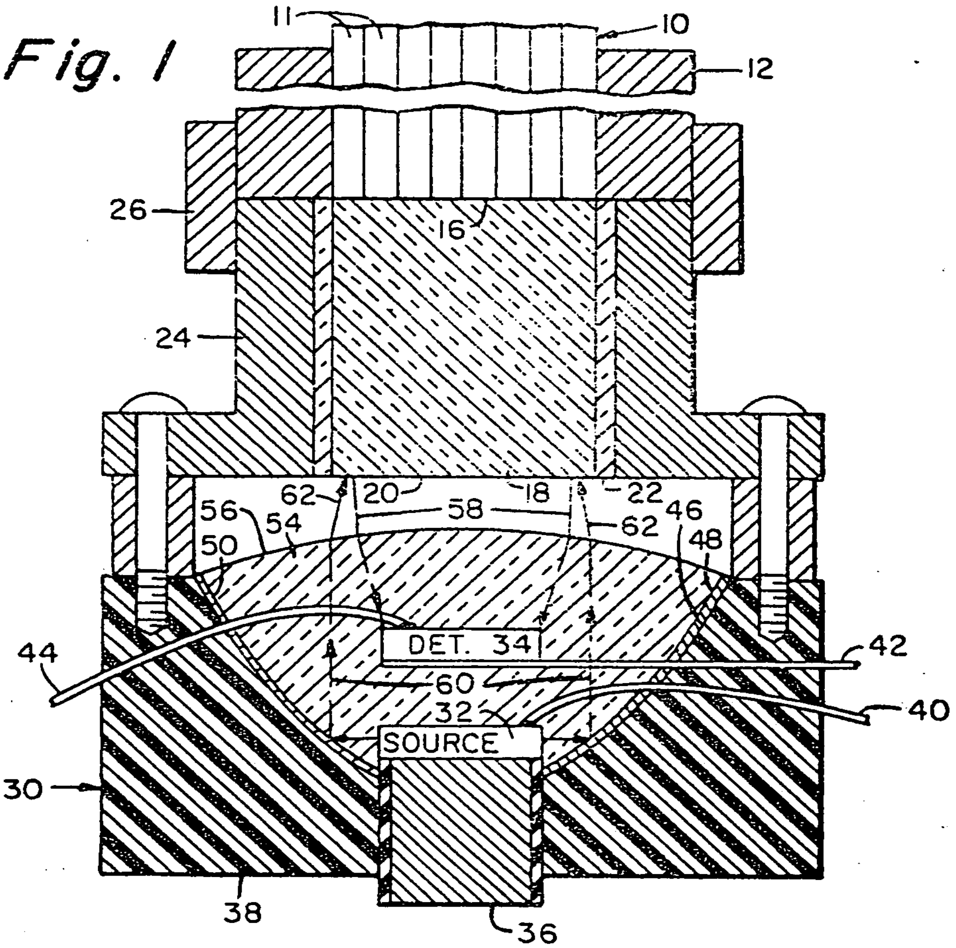

Fig. 2